Focusing Applied to Small-Angle Multispeckle XPCS Experiments

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XPCS performed with area detectors, so called multispeckle XPCS, has recently been extended to delay times as short as a several milliseconds [1,2] using fast and efficient direction-detection area detectors. But increasingly short delay times and the coherent flux limitations of third generation synchrotron sources require optimal use of the delivered undulator brilliance. For large collimating slit sizes, it has been shown [3] that the signal-to-noise ratio (SNR) for a measured autocorrelation decay function is maximized when the angular extent of the detector pixels as seen from the sample position matches that of the source as seen from the sample position. At a third-generation storage-ring x-ray source like the APS with a highly asymmetric source, this criterion presents an immediate problem because area-detector pixels are typically square. It is natural, therefore, to employ focusing optics to tailor the effective source sizes so that the resulting x-ray speckles approximately match the size of the detector elements. But since it is easy to degrade the effective brilliance of the beam via imperfect optics [4] it is also important to carefully characterize the effect of such optics on the coherence and stability of the x-ray beam. Here we report characterization of small angle x-ray speckle produced by a pinhole set-up, a Fresnel zone plate (FZP) set-up (and, possibly, a one-dimensional kinoform lens set-up). As compared to the pinhole set-up, we find for the FZP set-up that the speckle amplitude is approximately preserved but that the speckle widths are considerably greater and the signal per speckle is greatly increased. We compare our measurements to calculations. Our results demonstrate that strongly demagnifying optics like FZP's and kinoform lenses can be employed to produced virtual sources that fully utilize the brilliance delivered by third generation x-ray sources.

References

[1] P. Falus, M. A. Borthwick, S. Narayanan, A. R. Sandy, S.G. J. Mochrie, Phys. Rev. Lett. **97**, 066102 (2006).
[2] A. Madsen, http://www.esrf.eu/news/spotlight/spotlight39/spotlight39xpcs/.
[3] P. Falus, L.B. Lurio, and S. G. J. Mochrie, J. Synch. Rad. **13**, 253 (2006).
[4] I. A. Vartanyants and I. K. Robinson, Opt. Comm. **222**, 29 (2003).
[5] Z. Feng, "Experimental and Theoretical Investigation of the Coherent X-Ray Propagation and Diffraction," M.Sc. Diss., McGill University, 2006.